UNIT 14

RESPIRATION

Major Concept

14.1 Respiratory System of Man
14.2 Mechanism of Transport of Respiratory Gases
14.3 Respiratory Disorders

Learning Outcomes

Students will be able to:

- Define the respiratory surface and list its properties
- Describe the main structural features and functions of the components of human respiratory system
- Describe the ventilation mechanism in humans
- State lung volumes and capacities
- Explain how breathing is controlled
- Describe the transport of oxygen and carbon dioxide through blood
- Describe the role of respiratory pigments
- State the causes, symptoms and treatment of upper Respiratory Tract Infections (sinusitis, otitis media) and lower Respiratory Tract Infections (pneumonia, pulmonary tuberculosis)
- Describe the disorders of lungs (emphysema and lung cancer)
- List the effects of smoking on respiratory system

Introduction

For normal functioning of organisms chemical substances are needed, which must be transported into and around the body, while waste substances must be transported from where they are produced to outside.

Respiration is the one of most important processes in this respect. There are two levels of respiration *i.e.* external respiration and internal respiration.

External Respiration is also known as breathing which is the process of taking fresh air (containing more oxygen) into the respiratory organs (lungs) then to cells and removal of stale air (containing more CO_2) from respiratory surfaces or organs.

Internal Respiration is also known as cellular respiration. It is a catabolic process, releases energy from organic food molecules. The energy is released in the form of Adenosine Triphosphate (ATP) that is used for development, growth various bodily activities, repair damage parts and reproduction.

14.1 Respiratory System of Man

Respiratory system is responsible for the gaseous exchange between cells, body fluids (blood), respiratory surfaces and outer environment.

14.1.1 Properties of Respiratory Surfaces in Animals and Human

Respiratory surface are the areas where gaseous exchange between animals and environment occur. These surfaces in various animals are skin, tracheas, gills and lungs. The respiratory surfaces show following characteristics for readily exchange of gases through diffusion.

1. It should be large, moist and highly permeable for easy exchange of gases.
2. It should be thin epithelium (1mm or less) and also possess network of blood capillaries, which facilitate rapid transport and diffusion of gases between respiratory surface and blood.
3. A good ventilation mechanism should be present to maintain a steep diffusion gradient.

14.1.2 Components of Respiratory System of Man

This system can be divided into two main parts, the respiratory tract or air passage way and respiratory organs. The **respiratory tract** consists of external nostrils, nasal sacs or cavities, internal nares, pharynx, larynx, trachea, bronchi, bronchioles and alveolar ducts that terminate into the alveoli while respiratory organs are a pair of lungs.

14.1.3 Nose or Nasal Cavities

The human **nose** is the only externally visible parts of respiratory tract which is made of bones, cartilages and fatty muscle tissues. The external opening of nose is called

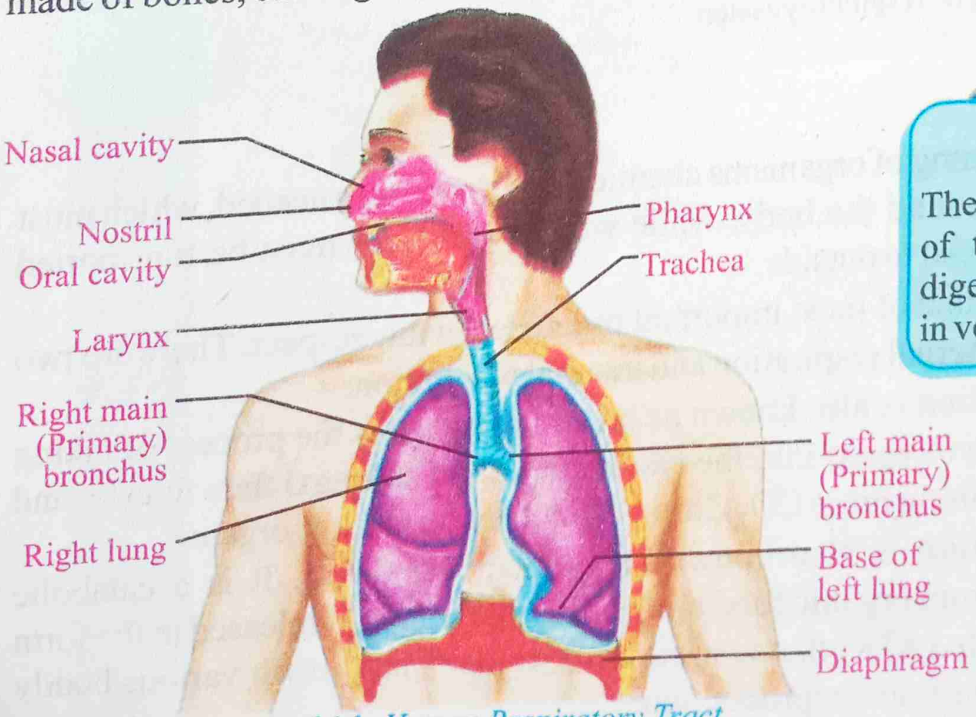


Fig. 14.1: Human Respiratory Tract

Extra Information

The throat or pharynx is part of the both respiratory and digestive system. It also helps in vocalization.

external nostrils. There is a nasal septum which separates two **nasal cavities** or **vestibules** from each other. These cavities contain a network of hair, lined by mucous membranes (secrete mucus) along with cilia, which serves as a defense mechanism against pathogens, trap dust and solid particulate substances present in the air. These substances are pushed to pharynx by cilia for removal.

The mucus also moists the air and brings the temperature of inhaled air close to body temperature about 30°C depending upon external temperature. (Fig.14.1)

14.1.4 Pharynx

The internal nostrils at the back of nose, opens the nose into the pharynx, which is muscular mucus secreting passage, cone shaped, conne-cts oral cavity and nasal cavities to the oesophagus and larynx. It consists of three sections, the **nasopharynx**, **oropharynx** and **laryngoph-arynx**. The inter connection of oral and pharyngeal cavity is medically beneficial to us, which allows to breath both by mouth and nose. (Fig.14.2)

14.1.5 Larynx

Larynx is also called **voice** or **sound box**. It is composed of cartilages and muscles, one of the cartilages that acts as a lid called **epiglottis**. During swallowing the epiglottis automatically covers the opening and cavity of larynx known as glottis. Two **vocal cords**, made of elastic fibres, placed horizontally in the lower side of glottis. The vibration of these cords produces voice. In adult male these cords are larger thus usually produce low pitched voices. (Fig. 14.3)

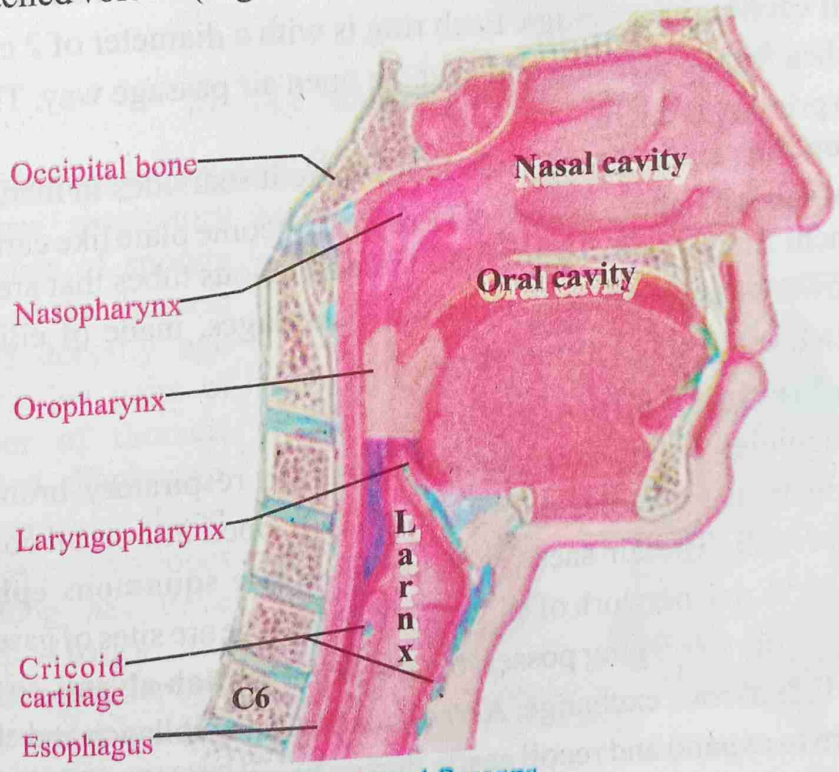


Fig. 14.2: Nasal Passage

There is a space between these membranes filled with fluid called **pleural fluid**. This fluid enables them to slide over one another and to prevent friction. (Fig. 14.5)

14.1.9 The Mechanism of Breathing (Ventilation)

The **breathing** is a mechanical process consisting of two phases *i.e.* inspiration or inhalation and expiration or exhalation. During **inspiration**, the fresh air containing more oxygen is pumped into the lungs while during **expiration** the air with more CO_2 is pumped out of the lungs. The lungs themselves neither draw in air nor push it out. The passive expansion of elastic lungs occur and also passive contraction of lungs occur during expiration. The complete expiration and contraction of the lungs is done by the combined action of **diaphragm, abdominal muscles** and **intercostal muscles** (muscles between the ribs).

During inspiration the space inside the chest is increased by two ways.

i) External rib muscles contract, which result in the upward and forward movement of the ribs, thus the pressure from the lungs is released and they expand.

ii) The muscles of diaphragm contract, lowering it and increasing the volume of the chest cavity.

Abdominal muscles relax to compensate for the compression of abdominal

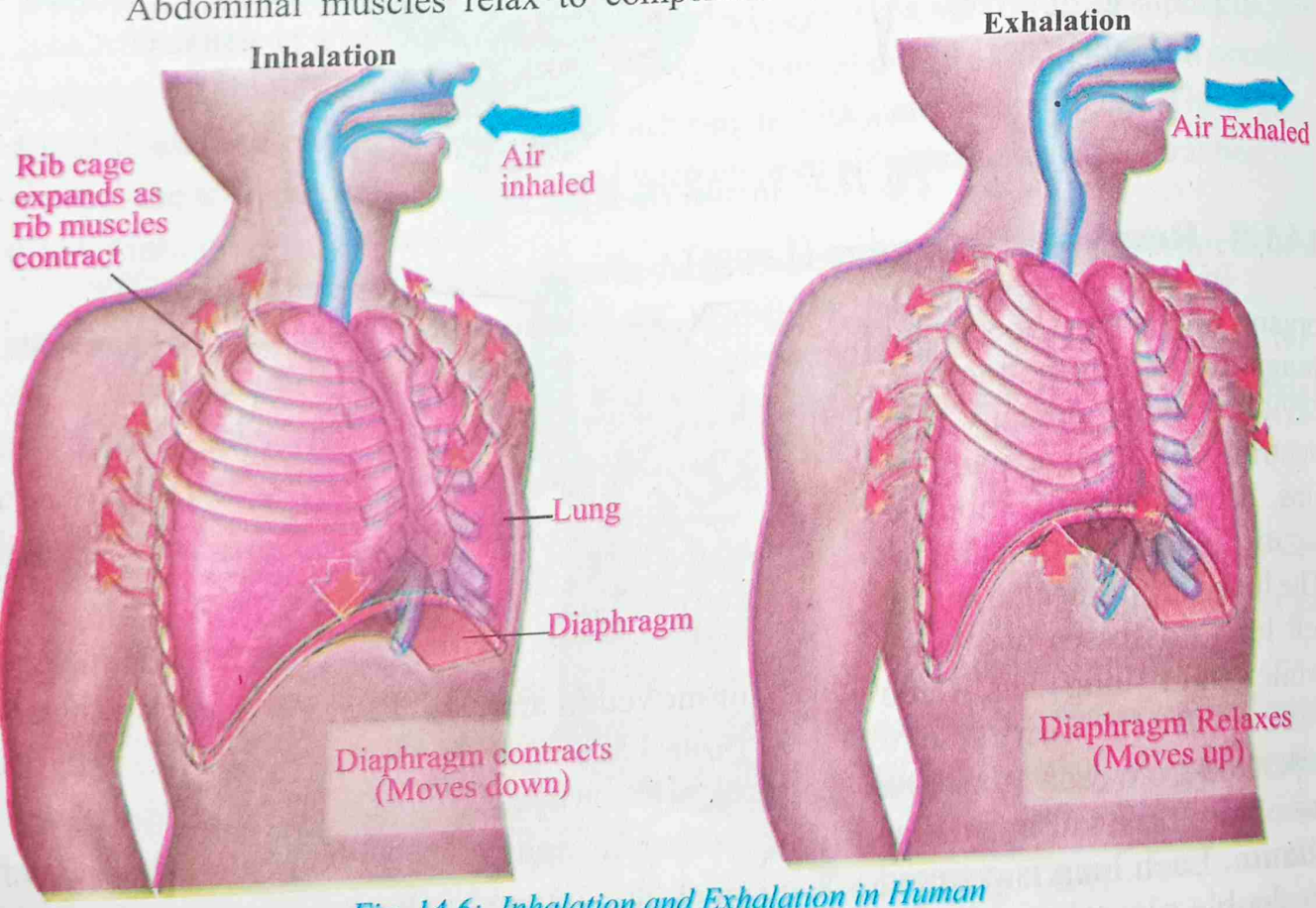


Fig. 14.6: Inhalation and Exhalation in Human

organs. The release of pressure from lungs by upward movement of ribs and increase in the chest cavity by downward movement of diaphragm causes the pressure in the chest cavity to drop below the atmospheric pressure and thus air rushes through the respiratory passage into the lungs to equalize the pressure inside and outside.

During expiration the volume of chest cavity is decreased. Muscles of the ribs are relaxed and the ribs move downward and inward, in this way from the side of the chest cavity the space becomes less.

At the same time the muscles of diaphragm also relax, the diaphragm projects into the thoracic cavity and become dome-shaped, therefore, the chest cavity is also reduced from the floor as well.

The abdominal muscles contract to push the abdominal organs against the diaphragm. The elastic lungs also contract and force the air to expel out. The reduction of space of the chest cavity exert pressure on the lungs thus the air inside the lungs move out of the lungs and this is known as expiration. (Fig. 14.6)

Table: 14.1 Differences between internal and external respiration

S.No.	External Respiration	Internal Respiration
i)	It is the exchange of respiratory gases (O_2 and CO_2) between the organism and its environment.	It is a biochemical process occurs within the cell to oxidize food molecules.
ii)	It is exchange of gases between circulatory fluid and external environment.	It is exchange of gases between the cell and circulatory fluid.
iii)	No ATP, H_2O are formed.	ATP, CO_2 and H_2O are produced.
iv)	It is aerobic respiration.	It may be aerobic or anaerobic respiration.

14.1.10 Lungs Respiratory Volumes and Capacities

The **respiratory volume** is also known as **pulmonary volume**, which is the amount of air inspired, expired and stored within lungs at any given time. It is the amount of air during breathing.

Tidal volume is the amount of air moved in and out with each quiet breath which is normally 500 ml during deep breath. We can increase the inspiration by as much as 3000 to 4000 ml of air during forced inspiration. This is known as **inspiratory reserve** volume. About 1200 – 1500 ml air always remains in the lungs (even during deep breath), this is called **residual volume**. (Fig. 14.7)

Extra Information

Spirometer is a device which helps to measure the respiratory volume and the process.

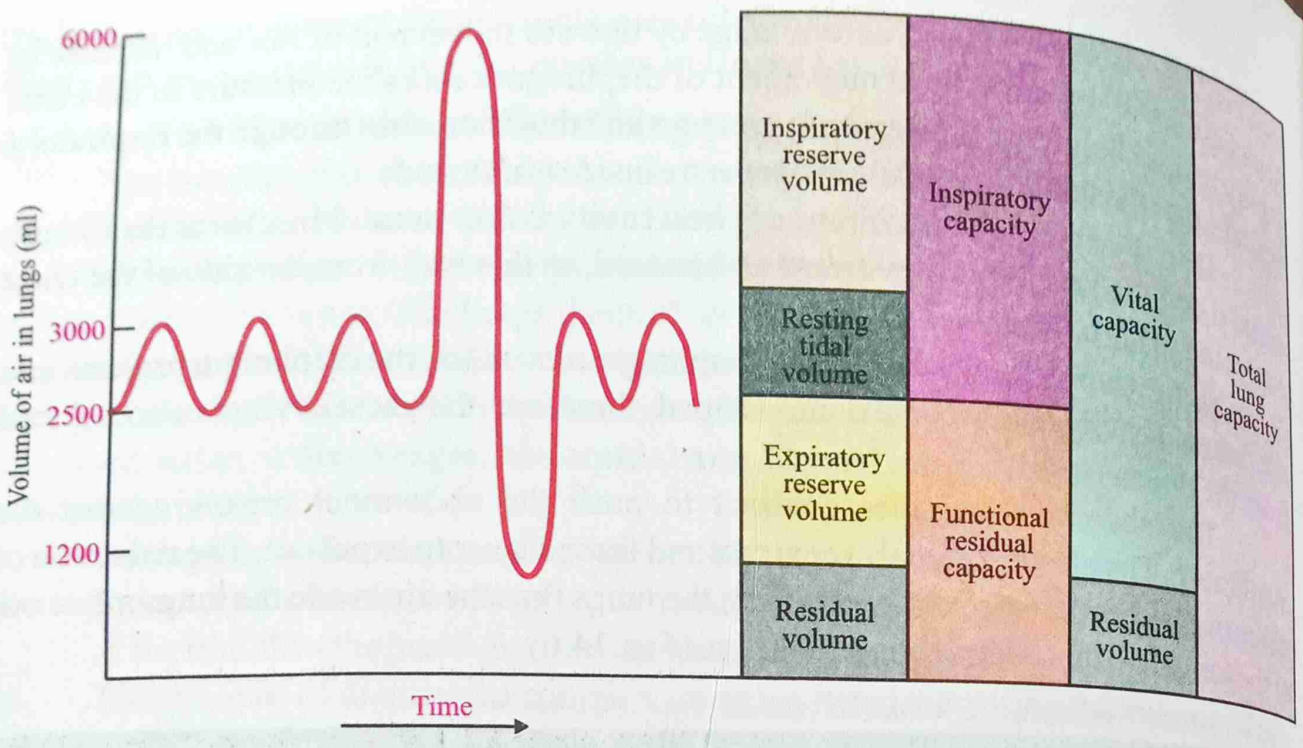


Fig. 14.7: Respiratory Volume

14.1.11 Controlling Centres of Breathing

Breathing is controlled both involuntarily and voluntarily. The **medulla** of our brain is controlling centre for involuntary breathing. The normal breathing rate is 15–20 times per minute. The voluntary or consciously control centre is **cerebral cortex of cerebrum** while **limbic system** of the brain also acts as respiratory centre during emotional acts.

Extra Information

The lower portion of medulla acts as inspiratory centre while upper and lateral portions acts as expiratory centres.

14.2 Mechanism of Transport of Respiratory Gases

Respiratory gases **(CO_2 and O_2)** are transported to various body regions by means of blood.

14.2.1 Respiratory Pigments and their Role

i) Haemoglobin is the most important respiratory pigment present in many animals including man. It is a complex protein consisting of four polypeptide chains *i.e.* 2 alpha chains and 2-beta chains having 574 amino acids. Each chain is associated with an haeme group. Haeme group is an iron containing group, which consists of **porphin** with a central atom of ferrous (iron) between four pyrrole rings. (Fig. 14.8)

Function of Haemoglobin

Haemoglobin is an iron containing protein in the red blood cells of vertebrates. It

transport oxygen to the tissues. Haemoglobin increases the oxygen carrying capacity of the blood in human to about 75 times. Iron in haemoglobin combines loosely with oxygen in the red blood cells (RBC) of pulmonary capillaries to form oxyhaemoglobin. This bright red blood containing oxyhaemoglobin is then circulates and reaches tissue and cells of the body where oxyhaemoglobin releases oxygen. This happens because haemoglobin has a property to release its oxygen where there is low concentration of oxygen and color of blood become purple red. After releasing oxygen, the haemoglobin returns back to the lungs with deoxygenated blood, to become again oxyhaemoglobin.

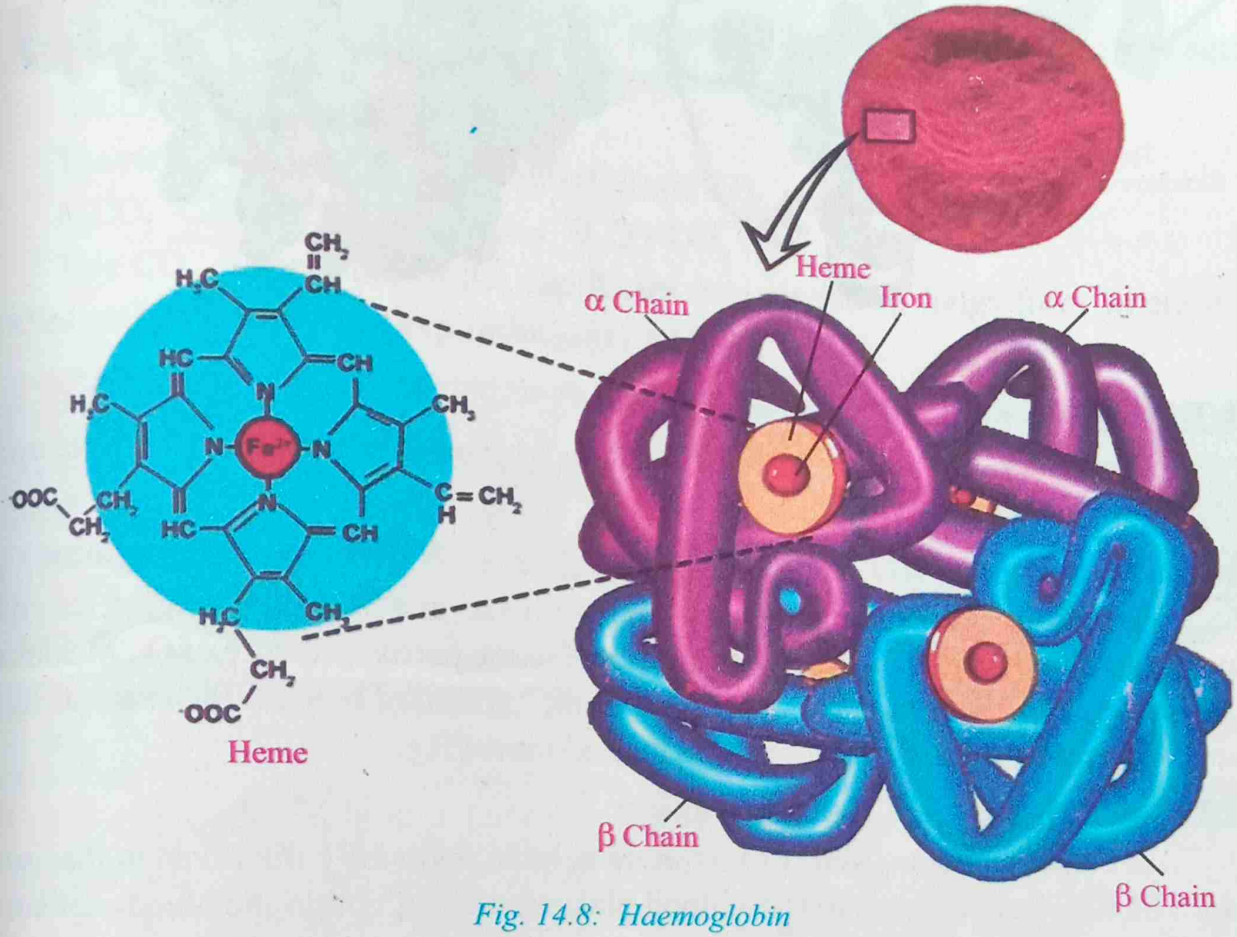


Fig. 14.8: Haemoglobin

ii) **Myoglobin** is another respiratory pigment in man, which is present in the muscle of human and other mammals. Therefore, meat is red. It is made of one iron containing polypeptide chain (contain 154 amino acids and bind only one molecule of oxygen).

Function of Myoglobin:- It stores oxygen in the muscle and gives oxygen when partial pressure of oxygen is below 20 mm of Hg. It has more affinity to combine with oxygen than haemoglobin. (Fig. 14.9)

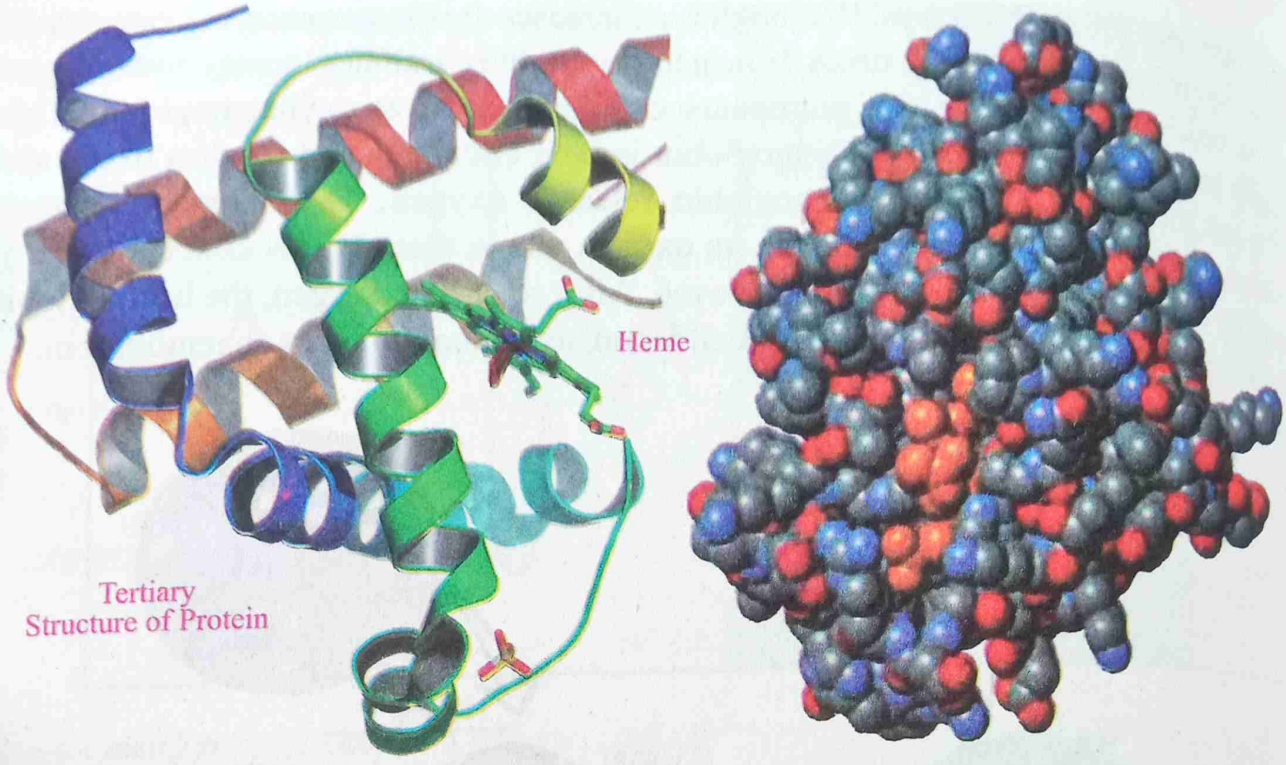


Fig. 14.9: Myoglobin

14.2.2 Transport of Oxygen in Blood

About 97-98% oxygen is carried by haemoglobin while remaining 2-3% transport as dissolved oxygen in plasma.

$$\text{Hb (Haemoglobin)} + 4O_2 \underset{}{\overset{\text{Carbonicanhydrase}}{\rightleftharpoons}} 4O_2\text{Hb (oxyhaemoglobin)}$$

The ability of haemoglobin to bind with oxygen is called oxygen carrying capacity of blood, which is directly proportional to the partial pressure of O_2. Maximum O_2 carrying capacity of blood at sea level is 20ml / 100ml of blood (100% saturated). It loses oxygen when partial pressure is less than 60 mm of Hg.

14.2.3 Transport of Carbon Dioxide

As compared to oxygen, CO_2 is more soluble and easily dissolved in the tissue fluid. The CO_2 from tissue passes to blood plasma, present within the blood capillaries where its transport occurs by three ways.

i) As bicarbonate ions (about 70%).
ii) As carboxyhaemoglobin (about 23%)
iii) As dissolved CO_2 in plasma (about 7%)

i) As bicarbonate ions (HCO_3)

First of all, the CO_2 is released as a result of oxidation reduction reaction and enters the plasma of the blood in tissue fluid. In blood, CO_2 combines in the presence of

an enzyme named as carbonic anhydrase with water inside RBCs and form carbonic acid.

$$CO_2 + H_2O \xrightarrow{\text{CarbonicAnhydrase}} H_2CO_3 \text{ (Carbonic Acid)}$$

The carbonic acid splits quickly and ionizes to form hydrogen ions (H^+) and bicarbonate ions (HCO_3).

$$H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

All these reactions are reversible. When the blood leaves the capillaries and comes into blood vessel all the CO_2 is now in the form of bicarbonates. Bicarbonates diffuse out of the red blood cells and carried by the plasma and H^+ is absorbed by the globin protein of haemoglobin.

When the blood reaches the alveoli of lungs capillaries, the bicarbonate ions again combine with H^+ ions to form carbonic acid again.

$$HCO_3^- + H^+ \rightleftharpoons H_2CO_3$$

The carbonic acid again splits into H_2O and CO_2

$$H_2CO_3 \xrightarrow{\text{CarbonicAnhydrase}} H_2O + CO_2$$

This CO_2 diffuses out of the capillaries into alveoli of lungs from where it is expelled out by the process of expiration. (Fig.14.10)

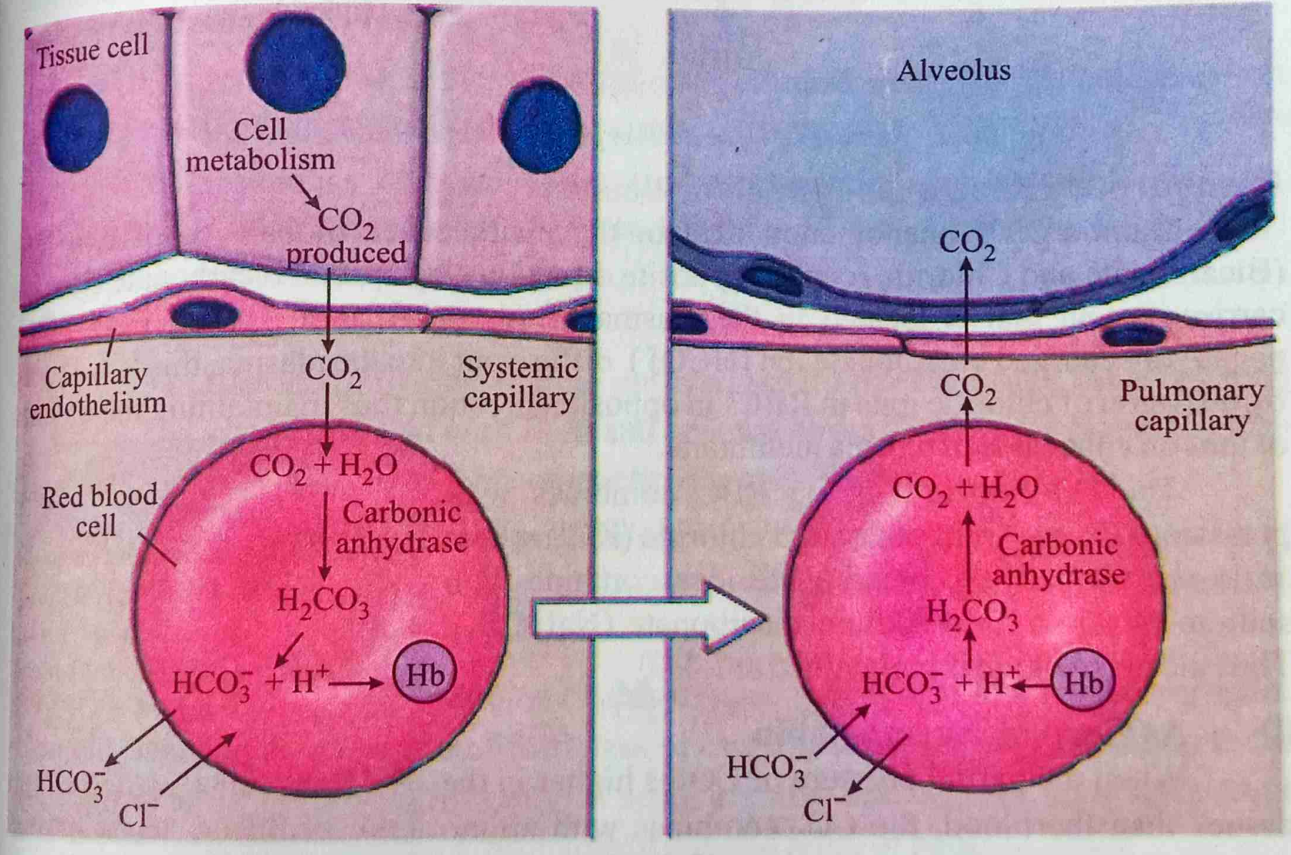


Fig. 14.10: Transport of CO_2 (From Cells to Alveolus)

Role of Hydrogen Ions

The pH of blood may decreases due to H^+ ions in the blood, but it does not occur since haemoglobin acts as buffer for Hydrogen ions. The oxyhaemoglobin readily combines with hydrogen ions to become reduced into **haemoglobin acid (HHb)** and oxygen is released to the tissues. (Fig.14.11)

$$4O_2\ Hb + H^+ \square\square\square \quad HHb + 4O_2$$

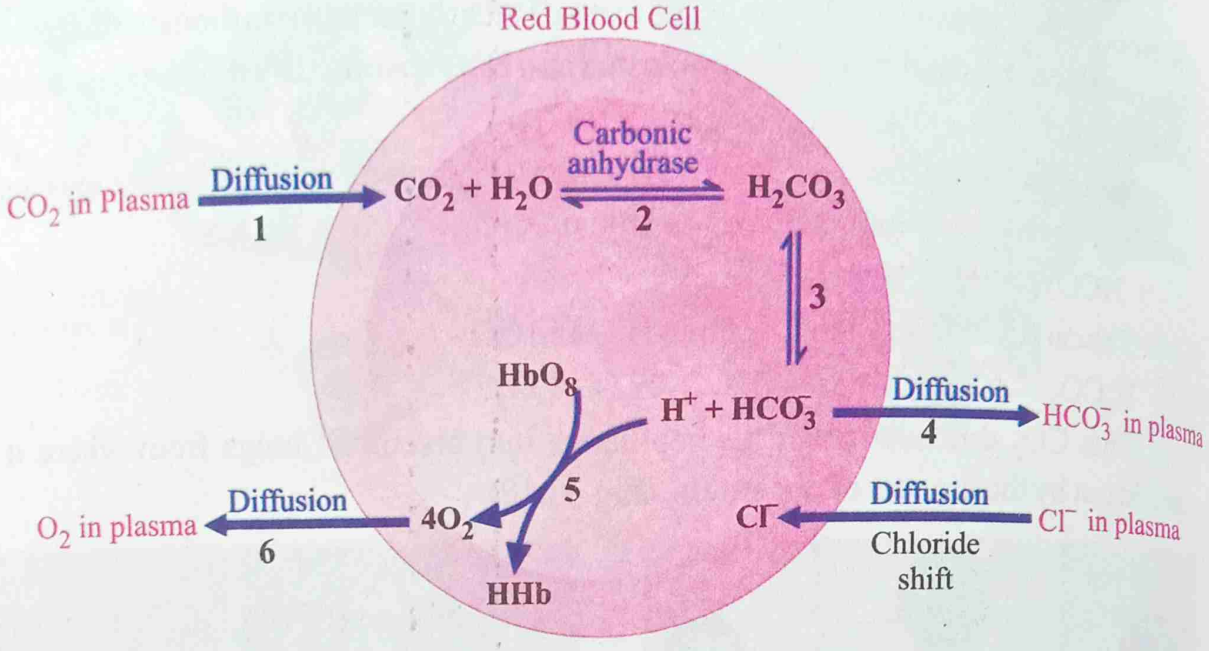


Fig. 14.11: Release of O_2 and Absorption in Blood Plasma and RBC

Hamburger`s Phenomenon or chloride shift

Hamburger`s phenomenon explain the maintenance of balance of two ions (Bicarbonate and Chloride Ions) in opposite directions, by special bicarbonate chloride carrier protein that is located in the plasma membrane of RBC. When from RBCs negatively charged bicarbonate ion (HCO_3^-) diffuse out into the plasma, this is balanced by diffusion of chloride ions in RBCs in opposite direction thus maintaining the balance of ions on either side of plasma membrane.

The chloride ion in the RBC combines with potassium (K^+) to form potassium chloride (KCl) where as in the plasma, the bicarbonate ions combine with sodium (Na^+) to form sodium bicarbonate ($NaHCO_3$). Thus the pH of blood is maintained at 7.4.

ii) As Carboxyhaemoglobin

When the partial pressure of CO_2 is higher in the tissues than the blood, the CO_2 combines with amino group of haemoglobin to form carboxyhaemoglobin. In

Extra Information

The CO_2 concentration. in arterial blood is 50ml / 100 ml of blood while venous blood contains 54 ml /100 ml blood, thus only 4 ml of CO_2 as it passes through the tissue-es and gives off 4 ml of CO_2 /100 ml of blood as it passes through the lungs.

the lungs the partial pressure of CO_2 is less than blood, it again breaks and releases CO_2.

iii) As Plasma Protein

Some CO_2 (about 7%) transported from tissue fluids to the lungs with the help of plasma proteins, which is rather inefficient way to carry CO_2.

14.3 Respiratory Disorders

Many problems in respiratory system can take place if inner lining of respiratory organs exposed continuously to unhealthy air, containing poisonous gases. (Such as smoke and other pollutants). Some common respiratory disorders are as under.

14.3.1 Upper Respiratory Tract Infections

i) Sinusitis

The **sinuses** are holes in the skull between the facial bones and inflammation in these holes is called sinusitis. So the **sinusitis** may be **acute** (if symptoms last 2-8 weeks) or **chronic** (slowly progress and symptoms last much longer).

The sinuses are lined with mucus secreting membrane, which secretes antibody rich mucus, helps to trap and prevent entry of irritants.

Interesting Information

There are four large sinuses, two maxillary lie inside the cheek bones and two frontal sinuses, lies above the eyes.

Causes: It is generally caused by atmospheric pollution, dust, smoke, cold and wet climate, excessive dryness and bacterial or viral infections, etc.

Treatment: Antibiotics or sulfa drugs are recommended for bacterial infection. Antiallergic and decongestants are also prescribed by doctors. Steam inhalation called **nebulization** is also useful to treat sinusitis.

ii) Otitis Media

It is an inflammation of the middle ear in which **Eustachian tube** (tube between middle ear and pharynx) filled with fluid and become close. If this fluid is not clear up after three months or more, then it becomes **chronic otitis media**.

Causes: The main causes of otitis media are infection, allergy, recurrent attacks of common cold, blockage of Eustachian tube, nutritional deficiency and sinusitis, measles, etc.

Symptoms: The common symptoms of this disease are sudden and severe ear ache, deafness, fever, headache, sense of fulfilness of ear, **tinnitus** (ringing or buzzing in the ear), fluid leaking from ear, difficulty in speaking and hearing, etc. Sometime even eardrum can burst, which causes a discharge of pus and relief of pain.

Treatment: Mostly (around 80% patients) treated by clearing up the fluid within three to four days, **ear drum** has self-repairing ability. However, for complicated cases antibiotic therapy is prescribed. Pain killers may be given to relieve pain and fever.

14.3.2 Lower Respiratory Tract Infections

i) Pneumonia

It is serious disorder of lower respiratory tract. Pneumonia is characterized by inflammation of alveolar wall and accumulation of fluid and pus in alveolar sacs of one or both lungs. (Fig.14.12)

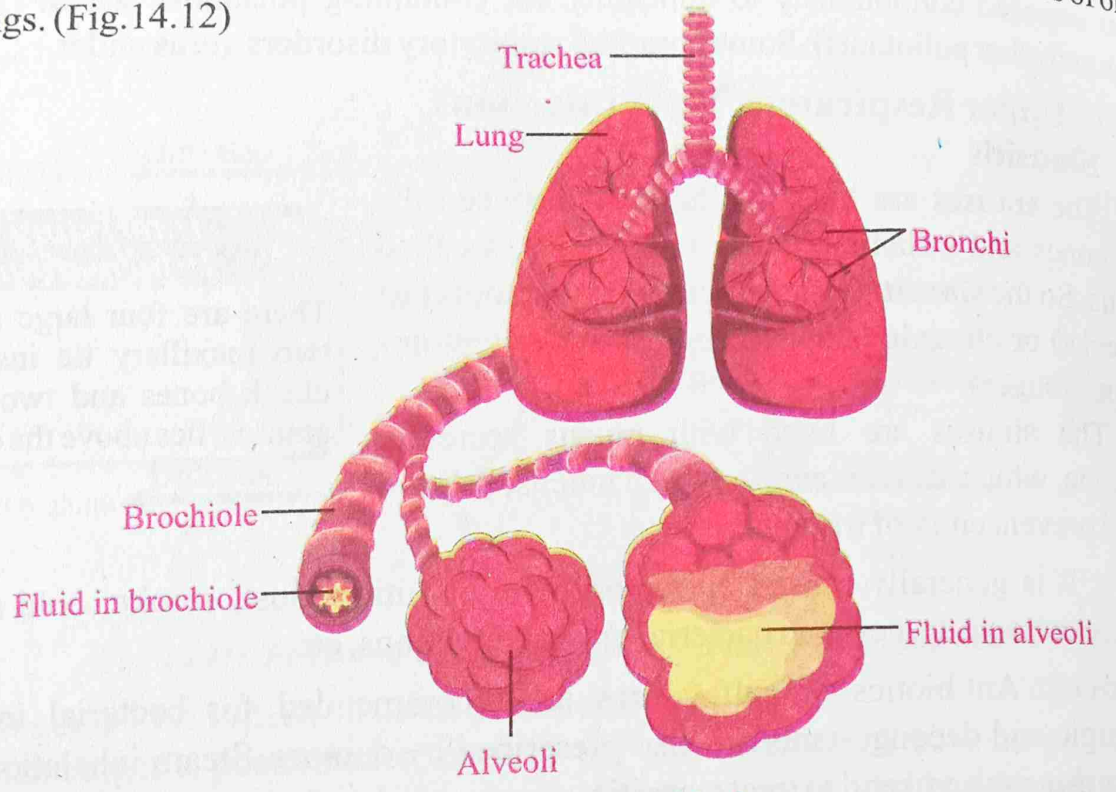


Fig. 14.12: Pneumonia of the Lungs

Causes: Mostly caused by bacterial genera such as ***Streptococcus pneumoniae, Staphylococcus aurexs, Haemophilus influenza and Mycoplasma,*** etc. Sometime it also occurs due to viral, fungal or protozoan infection.

Symptoms: The person with bacterial pneumonia may experience with chill, chattering teeth, shaking, chest pain, sweating due to high fever, increase pulse rate and breathing, violent coughing (due to *Mycoplasma*). In viral and other form dry cough, headache, fever and muscle pain, bluish color of lips, and red brown rusty color sputum are also symptoms of pneumonia.

Treatment: Mostly antibiotic treatment is prescribed.

ii) Lung Cancer

Cancer is **malignant tumor** which may develop due to uncontrolled cell division.

It is one of the most common cancer in the world.

Causes: Smoking and inhalation of unhealthy air. The chances of lung cancer are ten times more in those persons who smoke or live in crowded smoky areas. It is estimated that 90% of lung cancer is caused by smoking. (Fig.14.13)

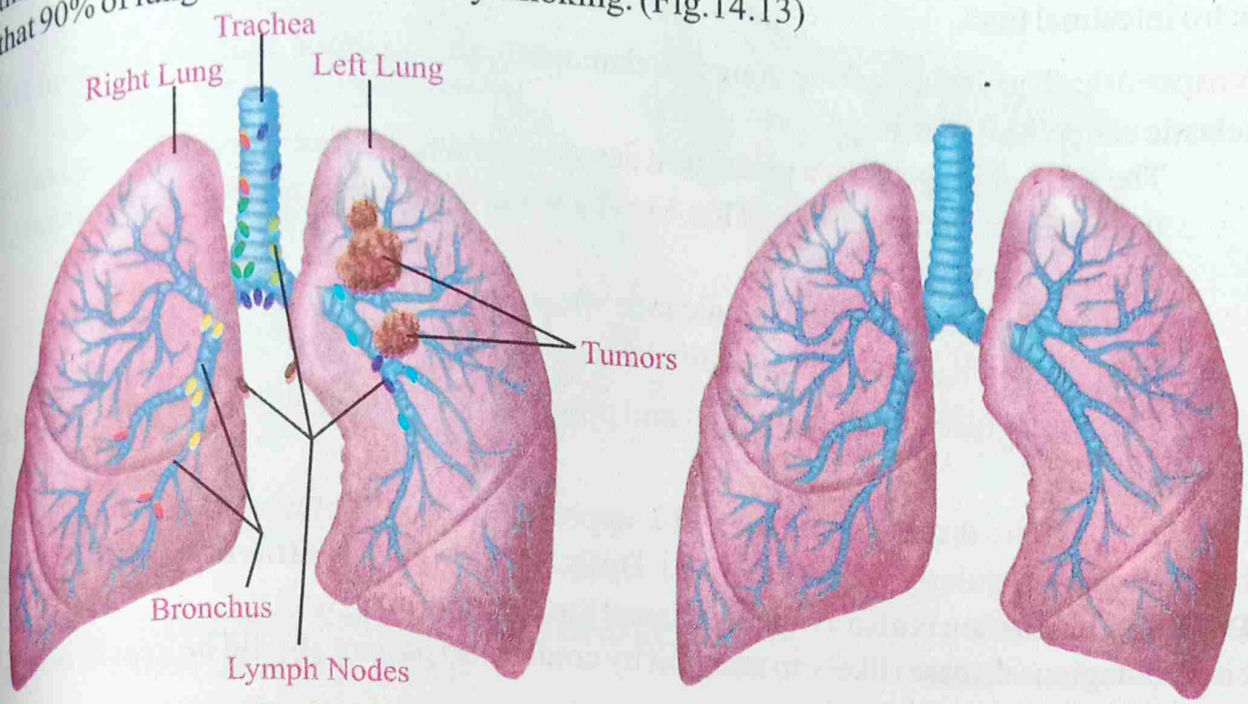


Fig.14.13: Lung Cancer (Cancerous and Healthy Lungs)

Symptoms: In initial stages the thickening and **callusing** (hardening) of cells occur, which are present in the lining of bronchi. The cilia in nasal passage (to prevent dust and dirt from seating in the lungs) are destroyed. The tumor consisting of disordered cells, spread and penetrates to other tissues known as **metastases**. These tumors grow until the bronchus is blocked and cutting off the supply of air to lung. The secretions are trapped in the spaces of lungs and become infected known as pneumonia or a lung abscess (swelling area containing pus) or only lung abscess result.

Extra Information

Pneumonectomy: Surgical removal of lung or part of lung.

Chemotheraphy: The use of chemical agents to treat or control diseases.

Radiotherapy: A therapy (Treatment) using ionizing radiation, generaly as a part of cancer treatment to control or kill malignant cell.

Treatment: To remove the tumor or the lung completely before the secondary growth has to occur. This operation is called **pneumonectomy**. **Chemotherapy** and **radiotherapy** may treat cancer.

iii) **Pulmonary Tuberculosis (TB)**

It is infectious bacterial disease of lower respiratory system. It is more common in

poor people due to poor living conditions and malnutrition.

Causes: Pulmonary tuberculosis is caused by a *Bacillus* bacterium known as ***Mycobacterium tubercle.*** Although about 15% develop TB of lymph nodes, joints and gastro intestinal tract.

Symptoms: The inside of the lungs is damaged, alveoli burst and are replaced by inelastic connective tissue.

- The cells of lungs form a protective capsule around the bacteria and isolated them from the rest of the body. This tiny capsule is called tubercle (small rounded swelling).
- The patient has cough, fever, pale face and sweating at night.
- In severe form, chest pain and breathlessness may occur.

Facilitating Condition: Malnutrition and poor living conditions facilitate the bacteria to grow.

Treatment: The disease is curable with appropriate drug therapy such as antibodies (for 9 months regularly). This is called **Daily Observed Treatment Short Course (DOTS)**. Vaccination is also available against the bacteria.
It is a contagious disease (likely to transmit by contact) so patient should be kept in isolate environment to prevent infection.

iv) Emphysema

It is a lung disorder in which the air sacs (alveoli) degenerate and the elastic fibers present in them are destroyed. As a result, alveolar wall degenerate and small alveoli combine to form larger alveoli. This results in less alveoli with an increased volume and decrease surface area for complete gaseous exchange.

Symptoms: Increasing breathlessness, patient faces difficulty in walking. Lung loses elasticity, so it becomes more difficult to exhale air and lot of air remains in the lung during expiration. Inflammation and narrowing of bronchioles occur. The patient feel fatigue, coughing and **cyanosis** (blue skin). (Fig. 14.14)

Causes: The root cause of emphysema is the long term irritation of the lungs by cigarette smoke, polluted air or industrial dust and exposure of lungs to certain drugs, coal, etc. The substances present in the smoke of tobacco weakens the walls of alveoli.

Treatment: There is no cure of emphysema but some care may be helpful.

- Avoid smoking.
- All kinds of respiratory infections should be treated immediately.
- Oxygen equipment and respiratory devices are helpful.

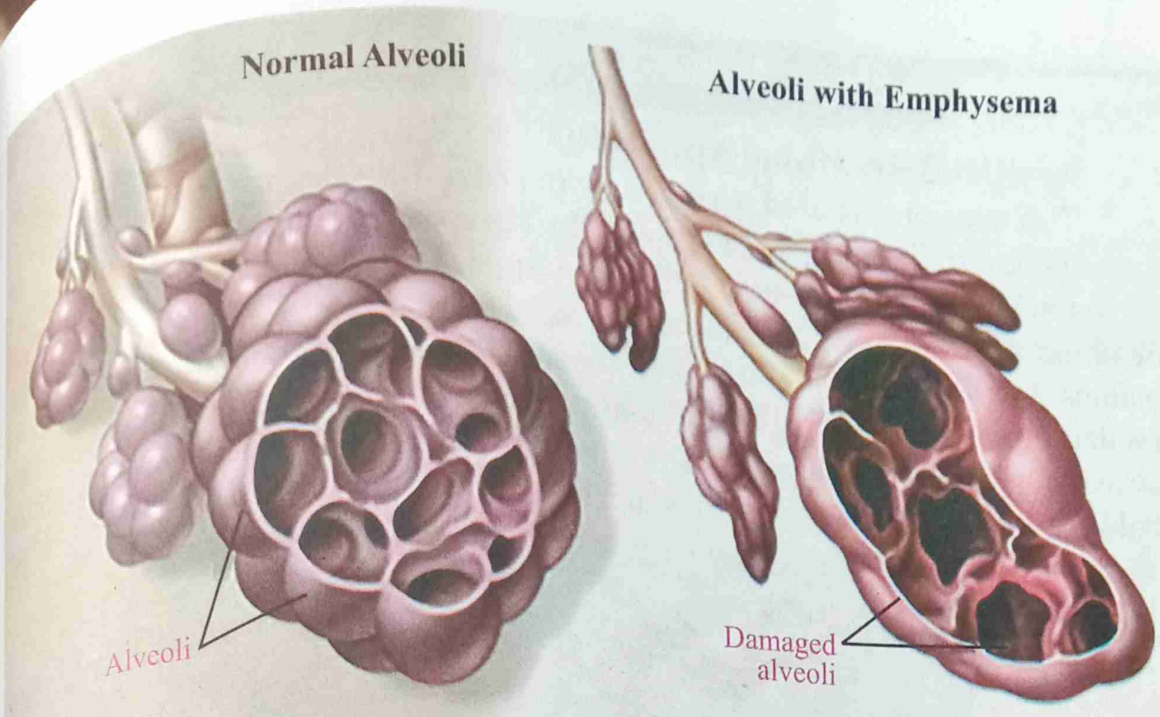
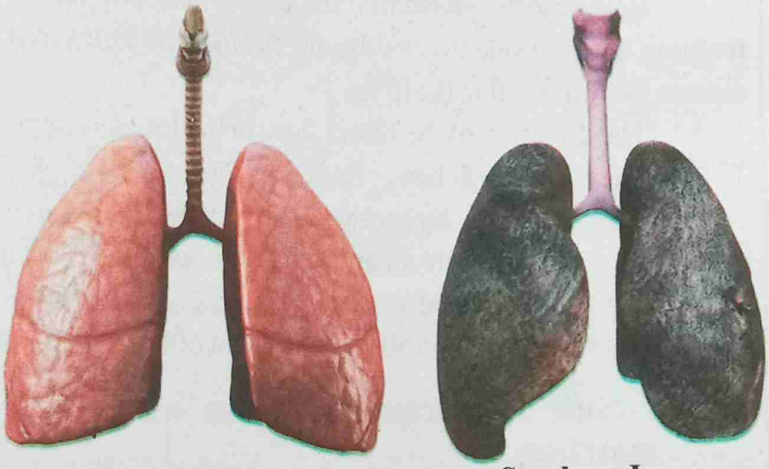


Fig. 14.14: Alveoli (Normal and Emphysema)

14.3.3 Effects of Smoking on Human Health

There are many effects of smoking on our respiratory system such as 87% of cigarette smokers also develop lung cancer. The smoking causes cancer of mouth, larynx and oesophagus. Smoking also causes many other diseases such as chronic bronchitis and emphysema.

The smoke of cigarette contains chemicals which irritate the respiratory tract and lung which results in early morning coughing and wheezing. It is indirect cause of pneumonia because cigarette smoke damages or destroys cilia. Thus microbes cannot be trapped and are easily settled in respiratory system. (Fig.14.15)



Healthy Lungs
In healthy people, the lungs are light pink

Smokers Lungs
In smokers, the lungs appear dark and mottled

Fig.14.15: Effects of Smoking

- **Artificial Breathing Apparatus**

This apparatus is used when we swim under the water and the areas with low oxygen concentration such as at high altitude. The apparatus is also used by fire fighter. It is commonly called **aqua-lung** or **SCUBA apparatus** (Self Contained Under Water Breathing Apparatus). It contains compressed air that is a mixture called **nitrox**, contains about 35% oxygen and 65% Nitrogen. The pressure of compressed air is much less than ambient pressure (The **ambient pressure** on an object is the pressure of the surrounding medium, such as a gas or liquid, in contact with the object), thus divers could breathe readily at any depth of water or areas with low oxygen.

- **Respiratory system in birds is the most efficient and elaborate. Why?**

Respiratory system in birds is the most efficient than other animals due the following features. There is one way of the air through the lungs and air is renewed after inspiration and also no foul air is left in the lungs.

The direction of the blood flow in the lungs is opposite to the air flow, the parabronchi. This counter current exchange increases the amount of oxygen which enters the blood.

Also birds have air sacs which reach into all parts of the body and even penetrates some bones. These air sacs store air and act as balloons and blow air into parabronchi for exchange of gases. This system provides a large amount of oxygen for the high metabolic rate, and birds can breathe and fly on high altitude of about 6000 meter or more.

- **Relate the transportation of gases to hiccups, sneezing and snoring.**

The hiccups, sneezing and snoring are the conditions which are related to breathing.

Hiccups:- It is sharp respiratory sound produced by the spasmodic contraction of the diaphragm while the glottis is closed. It is reflexive and serve no known functions but person feels difficulty in breathing.

Sneezing:- Deep inspiration followed by a closure of the glottis. The forceful expiration that results abruptly opens the glottis, sending a blast air through the nasal cavity. The eyelids close

EXERCISE

SECTION-I: OBJECTIVE QUESTIONS

Multiple Choice Questions (MCQs)

A. Select the correct answer.

1. Pleura is a double layered thin membrane that covers:
   (a) Heart (b) Liver
   (c) Kidney (d) Lungs

2. Hemoglobin in man increases the oxygen carrying capacity of the blood to about:
   (a) 75 times (b) 50 times
   (c) 60 times (d) 100 times

3. Plasma proteins are involved in the release of CO_2.
   (a) 70% (b) 7%
   (c) 30% (d) 20%

4. Structure, which closes the passage to lungs when food is coming, is called:
   (a) Glottis (b) Epiglottis
   (c) Uvula (d) Pharynx

5. Myoglobin loses oxygen at:
   (a) 60 mm Hg (b) 19.6 mm Hg
   (c) 90 mm Hg (d) 20 mm Hg

6. Breathing is an example of:
   (a) Diffusion (b) Osmosis
   (c) Ventilation (d) Cellular Respiration

7. The structure which prevents entry of food to wind pipe is called:
   (a) Glottis (b) Epiglottis
   (c) Tongue (d) Soft palate

8. Which one of the following lacks cartilage?
   (a) Trachea (b) Bronchioles
   (c) Bronchi (d) Larynx

9. The pleural fluid surround the:
   (a) Liver (b) Kidneys
   (c) Heart (d) Lungs

10. The percentage of CO_2 carried in the form of bicarbonate is:
    (a) 85% (b) 60%
    (c) 70% (d) 65%

11. Each molecule of myoglobin combines with one molecule of:
(a) Oxygen (b) Carbon dioxide
(c) Nitrogen (d) Sulphur

12. In human, respiratory pigment is:
(a) Haemocyanin (b) Haemoerythrin
(c) Chlorocrurin (d) Haemoglobin

13. The residual volume of air in human lung is
(a) 2.5 liter (b) 5.0 liter
(c) 1.5 liter (d) 3.0 liter

14. Chemotherapy and radiotherapy may help in the treatment of:
(a) Flu (b) Emphysema
(c) Lung cancer (d) Asthma

15. *Mycobacterium tubercle* causes:
(a) Emphysema (b) Sinusitis
(c) Pneumonia (d) Pulmonary tuberculosis

B. Fill in the blanks.

1. Respiratory surface must be permeable, so that ..... can pass through it.
2. The pharynx is part of both the respiratory and ..... system.
3. The trachea divides into two primary .....
4. Each lung contains about 35 millions .....
5. About 97- 98 % of O_2 is carried by the RBC as .....
6. The chloride shift is also called ..... phenomenon.
7. Sinusitis is an inflammation of nasal .....
8. Haemoglobin can carry ..... oxygen.
9. ..... media is an inflammation of middle ear.
10. Mycoplasma cause lower respiratory infection named .....